PROSTHETIC JOINT COMPONENT HAVING AT LEAST ONE SINTERED POLYCRYSTALLINE DIAMOND COMPACT ARTICULATION SURFACE AND SUBSTRATE SURFACE TOPOGRAPHICAL FEATURES IN SAID POLYCRYSTALLINE DIAMOND COMPACT

VI. Claims

We claim:

1. A component for use in a prosthetic joint, the component comprising:

a sintered polycrystalline diamond compact,

a substrate located on said polycrystalline diamond compact,

substrate surface topographical features located on said substrate, said substrate surface topographical features tending to increase surface area of contact between said substrate and a diamond table,

a diamond table sintered to said substrate on said polycrystalline diamond compact,

a gradient transition zone between said substrate and said diamond table,

chemical bonds between said diamond table and said substrate which tend to secure said diamond table to said substrate, and

a load bearing and articulation surface on said polycrystalline diamond compact, said load bearing and articulation surface including polycrystalline diamond, said load bearing and articulation surface being formed to present a surface that accommodates joint articulation.

2. A joint component as recited in claim 1 wherein diamond in said

polycrystalline diamond compact has a coefficient of thermal expansion CTE_{Cd}, and wherein said substrate in said polycrystalline diamond compact has a coefficient of thermal expansion CTE_{sub}, and wherein CTE_{Cd} is not equal to CTE_{sub}.

3. A joint component as recited in claim 1 wherein said diamond in said polycrystalline diamond compact has a modulus M_{Cd}, and wherein said substrate in said polycrystalline diamond compact has a modulus M_{sub}, and wherein M_{Cd} is not equal to M_{sub}.

4. A joint component as recited in claim 1 further comprising a mechanical grip between said diamond table and said substrate, said mechanical grip tending to secure said diamond table to said substrate, and said mechanical grip being present where substrate surface topographical features contact diamond.

5. A joint component as recited in claim 1 further comprising a residual stress field in said polycrystalline diamond compact that tends to enhance the strength of said polycrystalline diamond compact, characteristics of said residual stress field being determined at least in part by the nature of said substrate surface topographical features.

6. A joint component as recited in claim 1 wherein said substrate has a general surface shape; and wherein at least some of said substrate surface topographical features protrude away from said substrate general surface shape.

7. A joint component as recited in claim 1 wherein said substrate has a general surface shape, and wherein at least some of said substrate surface topographical features are formed by substrate material that does not extend completely to said substrate general surface shape.

8. A joint component as recited in claim 5 wherein said substrate surface

topographical features mitigate intensity of said stress field.

9. A joint component as recited in claim 5 wherein said substrate surface topographical features tend to distribute said stress field over a larger surface area than if said substrate surface topographical features were absent.

10. A joint component as recited in claim 9 wherein said substrate surface topographical features tend to limit peak stresss in said polycrystalline diamond compact.

11. A joint component as recited in claim 5 wherein said substrate surface topographical features serve at least in part to increase the depth of said gradient transition zone compared to the depth said gradient transition zone would have absent said substrate surface topographical features.

12. A joint component as recited in claim 6 wherein said substrate surface topographical features serve at least in part to distribute said residual stress field through a larger volume of diamond and substrate materials than if said substrate surface topographical features were not present.

13. A joint component as recited in claim 5 wherein said substrate surface topographical features serve at least in part to distribute residual stress in said polycrystalline diamond compact throughout the polycrystalline diamond compact structure in order to diminish stress per unit volume of structure compared to stress per unit volume in the polycrystalline diamond compact if said substrate surface modifications were not present.

14. A joint component as recited in claim 4 wherein said mechanical grip is created by substrate dilitation during cooling after sintering the polycrystalline diamond compact.

15. A joint component as recited in claim 4 where a dovetail is present between said diamond and said substrate in said gradient transition zone.

16. A joint component as recited in claim 1 wherein said substrate surface topographical features are selected from the group consisting of protruding and indented features.

17. A joint component as recited in claim 1 wherein said substrate surface topographical features serve at least in part to interlock said diamond table and said substrate.

18. A joint component as recited in claim 1 wherein said substrate surface topographical features serve at least in part to redistribute forces applied to the joint in order to mitigate crack formation, cleavage, and crack propogation in said diamond table.

19. A joint component as recited in claim 1 wherein said substrate surface topographical features are selected from the group consisting of waves, straight grooves, curved grooves, straight ridges, curved ridges, dimples, holes, protrusions, depressions, spherical segment depressions, spherical segment protrusions, hemispherical concave cups, hemispherical convex protrusions, partially spherical convex shapes, lines, curved lines, polygonal depressions, polygonal protrusions, cylindrical depressions, cylindrical protrusions, frusto-conical depressions, frusto-conical protrusions, waffle iron patterns and waffle patterns.

20. A component for use in a prosthetic joint, the component comprising:

a generally spherical substrate,

topographical features located on said substrate,

a diamond table sintered to said substrate in order to form a sintered

polycrystalline diamond compact,

a load bearing and articulation surface on said polycrystalline diamond compact, said load bearing and articulation surface including polycrystalline diamond, said load bearing and articulation surface being formed to present a surface that accommodates joint articulation.

21. A joint component as recited in claim 20 wherein said substrate surface topographical features tend to provide a greater surface area of contact between said substrate and a diamond table than the surface area of contact would be without said topographical features.

22. A joint component as recited in claim 20 further comprising chemical bonds between said substrate and said diamond table.

23. A joint as recited in claim 20 further comprising a mechanical grip between said substrate and said diamond table.

24. A joint as recited in claim 20 further comprising a zone of composition gradient in which both diamond and substrate metal are found.

25. A joint as recited in claim 20 said topographical features are selected from the group consisting of waves, straight grooves, curved grooves, straight ridges, curved ridges, dimples, holes, protrusions, depressions, spherical segment depressions, spherical segment protrusions, hemispherical concave cups, hemispherical convex protrusions, partially spherical convex shapes, lines, curved lines, polygonal depressions, polygonal protrusions, cylindrical depressions, cylindrical protrusions, frusto-conical depressions, frusto-conical protrusions, waffle iron patterns and waffle patterns.

26. A joint component as recited in claim 20 further comprising a first

topographical feature that is a depression to a first depth and a second topographical feature that is a depression to a second depth, wherein said first depth is not equal to said second depth.

27. A joint component as recited in claim 26 wherein said second depression is located in said first depression.

28. A joint component as recited in claim 27 wherein said first and second depressions have an outer periphery shape that is selected from the group consisting of round and polygonal.

29. A joint component as recited in claim 27 further comprising a third topographical feature that is a depression to at third depth, wherein said third depth is not equal to said second depth, and said third depth is not equal to said first depth.

30. A joint component as recited in claim 29 wherein at least one of said depressions has an outer periphery shape selected from the group consisting of round and polygonal.

31. A joint component as recited in claim 30 wherein said substrate includes CoCr as a solvent-catalyst metal.

32. A joint component as recited in claim 20 said substrate includes a metal selected from the group consisting of titanium, aluminum, vanadium, molybdenum, hafnium, nitinol, cobalt, chrome, molybdenum, tungsten, cemented tungsten carbide, cemented chrome carbide, fused silicon carbide, nickel, tantalum, and stainless steel.

33. A joint component as recited in claim 20 wherein diamond in said polycrystalline diamond compact has a coefficient of thermal expansion CTE_{Cd}, wherein said substrate has a coefficient of thermal expansion CTE_{sub}, and wherein CTE_{Cd} is not

equal to CTE_{sub}.

34. A joint component as recited in claim 20 wherein diamond in said polycrystalline diamond compact has a modulus M_{Cd}, wherein said substrate has a modulus M_{sub}, and wherein M_{Cd} is not equal to M_{sub}.

35. A component for use in a prosthetic joint, the component comprising:

a generally spherical polycrystalline diamond compact,

a diamond table on said polycrystalline diamond compact, said diamond table including polycrystalline diamond,

a substrate located on said polycrystalline diamond compact,

an interface between said substrate and said diamond table,

chemical bonds between said substrate and said diamond table, and

a load bearing and articulation surface located on said polycrystalline diamond compact, said load bearing and articulation surface being formed at least in part by polycrystalline diamond of said diamond table, said load bearing and articulation surface being formed to present a surface that accommodates joint articulation.

36. A joint component as recited in claim 35 wherein said diamond table covers only a portion of the exterior surface of said substrate.

37. A joint component as recited in claim 36 wherein said polycrystalline diamond compact has a radius R1; wherein said substrate beneath said diamond table has a partially spherical shape; wherein said substrate partially spherical shape beneath said diamond table has a radius R2; and wherein R1 > R2.

38. A joint component as recited in claim 37 further comprising topographical features on said substrate beneath said diamond table.

39. A joint component as recited in claim 38 wherein said topographical features are selected from the group consisting of waves, straight grooves, curved grooves, straight ridges, curved ridges, dimples, holes, protrusions, depressions, spherical segment depressions, spherical segment protrusions, hemispherical concave cups, hemispherical convex protrusions, partially spherical convex shapes, lines, curved lines, polygonal depressions, polygonal protrusions, cylindrical depressions, cylindrical protrusions, frusto-conical depressions, frusto-conical protrusions, waffle iron patterns and waffle patterns.

40. A joint component as recited in claim 35 further comprising substrate surface topographical features.

41. A joint component as recited in claim 40 wherein said substrate surface topographical features tend to provide a greater surface area of contact between said substrate and a diamond table than the surface area of contact would be without said topographical features.

43. A joint component as recited in claim 40 wherein said topographical features serve to redistribute forces applied to said polycrystalline diamond compact.

44. A joint as recited in claim 40 wherein said topographical features serve to mitigate crack formation and propogation in said polycrystalline diamond compact.

45. A joint as recited in claim 40 wherein said topographical features serve to distribute residual stress through said polycrystalline diamond compact.

46. A joint as recited in claim 40 wherein said topographical features serve to provide a strong mechanical grip between said diamond table and said substrate.

47. A joint as recited in claim 35 further comprising a neck located on said

polycrystalline diamond compact, said neck protruding from the generally spherical periphery of said polycrystalline diamond compact, and the neck serving as an attachment point for the joint component.

48. A joint component as recited in claim 47 wherein said diamond table covers substantially all of the joint component except the neck.

49. A joint component as recited in claim 47 further comprising substrate topographical features.

50. A joint as recited in claim 49 wherein said topographical features are selected from the group consisting of waves, straight grooves, curved grooves, straight ridges, curved ridges, dimples, holes, protrusions, depressions, spherical segment depressions, spherical segment protrusions, hemispherical concave cups, hemispherical convex protrusions, partially spherical convex shapes, lines, curved lines, polygonal depressions, polygonal protrusions, cylindrical depressions, cylindrical protrusions, frusto-conical depressions, frusto-conical protrusions, waffle iron patterns and waffle patterns.

51. A joint as recited in claim 35 wherein at least some of said substrate surface topographical features are radiused in order to avoid generation of stress concentrations.

52. A prosthetic joint comprising:

a substrate that includes a solvent-catalyst metal,

substrate surface topographical features located on said substrate,

a diamond layer sintered to said substrate,

a zone between said substrate and said diamond layer that has a composition

gradient of decreasing solvent-catalyst metal content across said zone,

chemical bonds in said zone, said chemical bonds including diamond-to-diamond bonds in said diamond table, diamond-to-metal bonds in said gradient transition zone, and metal-to-metal bonds in said solvent-catalyst metal.

a mechanical grip between said diamond layer and said substrate which tends to secure said diamond layer to said substrate, said mechanical grip being created at least in part by said substrate surface topographical features,

interstitial spaces in said diamond layer,

solvent-catalyst metal present in said interstitial spaces, and

a non-planar load bearing and articulation surface formed by said diamond layer.

53. A component as recited in claim 52 wherein sintered diamond in said diamond layer has a coefficient of thermal expansion CTE_{Cd}, and wherein said substrate has a coefficient of thermal expansion CTE_{sub}, and wherein CTE_{Cd} is not equal to CTE_{sub}.

54. A component as recited in claim 52 wherein said sintered diamond in said diamond layer has a modulus $M_{Cd,}$ and wherein said substrate has a modulus M_{sub}, and wherein $M_{Cd,}$ is not equal to M_{sub}.

55. A component as recited in claim 52 further comprising a residual stress field that tends to enhance the strength of attachment of said diamond layer to said substrate.

56. A component as recited in claim 52 further comprising substrate surface topographical features on said substrate.

57. A component as recited in claim 52 wherein said substrate includes a metal alloy with at least one component of said metal alloy being selected from the group consisting of titanium, aluminum, vanadium, molybdenum, hafnium, nitinol, cobalt, chrome,

molybdenum, tungsten, cemented tungsten carbide, cemented chrome carbide, fused silicon carbide, nickel, tantalum, and stainless steel.

58. A component as recited in claim 52 wherein diamond layer comprises diamond feedstock that has diamond particles that have a dimension in the range of less than about 1 nanometer to more than about 100 microns.

59. A component as recited in claim 52 wherein said diamond load bearing and articulation surfaces is a continuous diamond surface.

60. A component as recited in claim 52 wherein said diamond load bearing and articulation surface is a discontinuous diamond surface.

61. A component as recited in claim 52 wherein said diamond load bearing and articulation surface is a segmented diamond surface.

62. A component as recited in claim 52 wherein a lip is present on said substrate in order to interlock said diamond layer to said substrate.

63. A component as recited in claim 52 further comprising CoCr solvent-catalyst metal in said diamond table interstitial spaces.

64. A component as recited in claim 52 further comprising a continuous gradient in said diamond layer.

65. A component as recited in claim 52 further comprising an incremental gradient in said diamond layer.

66. A component as recited in claim 65 wherein said incremental gradient includes a plurality of strata in said diamond layer, a first of said strata having characteristics which differ from those of a second strata.

67. A component as recited in claim 66 wherein said differing characteristics of said strata are selected from the group consisting of diamond particle size, diamond particle distribution, and solvent-catalyst metal content.

68. A component as recited in claim 52 further comprising an interface gradient.

69. A component as recited in claim 52 wherein said diamond layer has a thickness of from less than about 1 micron to more than about 3000 microns.

70. A prosthetic joint comprising:

a substrate,

a diamond layer sintered to said substrate,

interstitial spaces located in said diamond layer,

solvent-catalyst metal located in said interstitial spaces,

a zone that includes both sintered diamond and substrate, said zone having a composition gradient of solvent-catalyst metal content to diamond content, said gradient being selected from the group consisting of interface gradient, continuous gradient and incremental gradient,

chemical bonds in the component, said chemical bonds including diamond-to-diamond bonds in said diamond layer, diamond-to-metal bonds in said zone, and metal-to-metal bonds in said solvent-catalyst metal,

a mechanical grip between said diamond layer and said substrate which tends to secure said diamond layer to said substrate, and

a non-planar load bearing and articulation surface formed by said diamond layer.

71. A component as recited in claim 70 further comprising a lip of substrate material which serves to hold said diamond layer in place adjacent said substrate.

72. A component as recited in claim 70 further comprising a dovetailed interlock between said diamond table and said substrate.

73. A component as recited in claim 70 further comprising a lip on said substrate that interlocks said substrate with said diamond table.

74. A component as recited in claim 70 wherein at least some of said bonds are sp3 carbon bonds.

75. A component as recited in claim 70 wherein said diamond table includes a plurality of strata such that a first of said strata having characteristics which differ from those of a second strata.

76. A component as recited in claim 75 wherein said differing characteristics are selected from the group consisting of diamond particle size, diamond particle distribution, and solvent-catalyst metal content.

77. A component as recited in claim 70 wherein said diamond table is formed using CoCr as a solvent-catalyst metal.

78. A component as recited in claim 70 further comprising a plurality of diamond strata in said zone.

79. A component as recited in claim 70 wherein said diamond table presents a non-planar diamond load bearing and articulation surface.

80. A component as recited in claim 70 wherein said interstitial spaces are filled with a metal.

81. A component as recited in claim 70 wherein said interstitial spaces are filled with solvent-catalyst metal.

82. A component as recited in claim 70 further comprising a transition zone in said

substrate.

83. A joint as recited in claim 70 wherein said substrate surface topographical features are selected from the group consisting of waves, straight grooves, curved grooves, straight ridges, curved ridges, dimples, holes, protrusions, depressions, spherical segment depressions, spherical segment protrusions, hemispherical concave cups, hemispherical convex protrusions, partially spherical convex shapes, lines, curved lines, polygonal depressions, polygonal protrusions, cylindrical depressions, cylindrical protrusions, frusto-conical depressions, frusto-conical protrusions, waffle patterns and waffle iron patterns.